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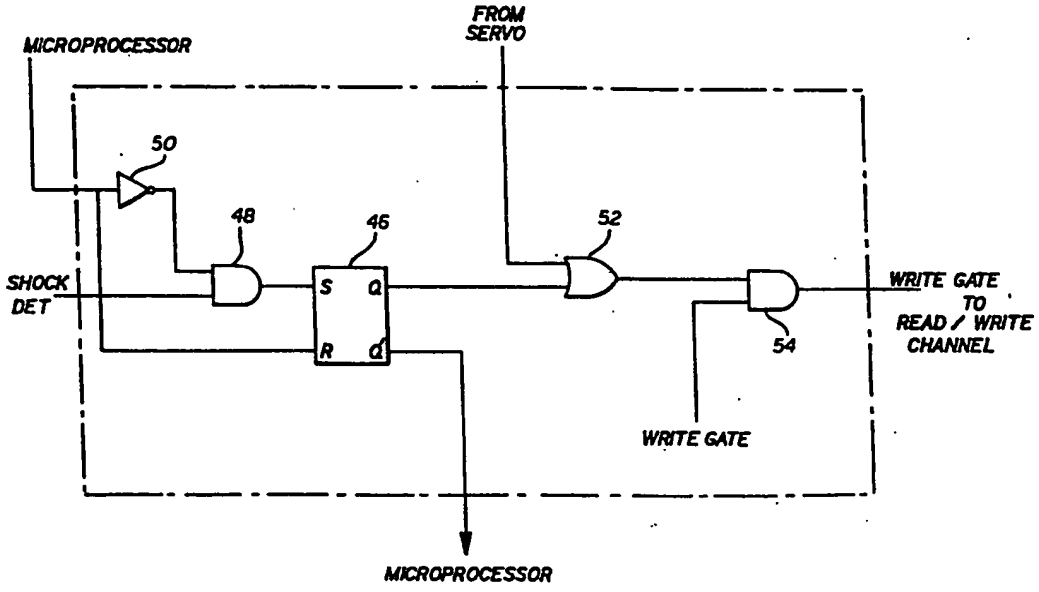
(54) Title: WRITE DISABLE ACCELERATION SENSING SYSTEM FOR A HARD DISK DRIVE




(57) Abstract

A sensor system which disables the write gate (54) of a hard disk drive (10) when the drive unit is subjected to a threshold level of shock or vibration. The sensor system includes a transducer (46) which can sense any rotational acceleration of the disk drive (10). The transducer (46) produces an output voltage that is proportional to the acceleration of the drive unit. The output voltage is compared to a reference voltage by a logic circuit which disables the write gate (54) of the disk drive (10), if the output voltage of the transducer (46) is equal to or greater than the reference voltage.

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# WRITE DISABLE ACCELERATION SENSING SYSTEM FOR A HARD DISK DRIVE

## BACKGROUND OF THE INVENTION

### 1. FIELD OF THE INVENTION

The present invention relates to a hard disk drive which has a sensor system that disables the write gate of the magnetic head when a shock or vibrational load of a predetermined value is applied to the disk drive.

### 2. DESCRIPTION OF RELATED ART

Hard disk drives contain one or more magnetic disk which are typically organized into a plurality of annular tracks. Data is stored within the disk drive by locating a magnetic head above a particular track and then magnetizing the disk. The magnetic head is mounted to an actuator arm which can move the head to any of the track locations. The tracks may have segments which contain coded information that uniquely identify each track. Proper track location can be obtained by reading the coded information within the track segments and moving the magnetic head accordingly.

To reduce system errors, it is desirable to locate the magnetic head within the boundaries of each track during the read and write operations of the disk drive. If the magnetic head is moved toward an adjacent track by an external disturbance, the data in the adjacent track can be corrupted if a write operation is in progress. For example, if the

magnetic head moves while the system is writing, the new data may write over the old data on the adjacent track, resulting in an unrecoverable loss of the old data.

Present hard disk drives typically prevent head movement by employing either a continuous servo system or a sample servo system. In a sample servo system, each track contains a segment(s) which has embedded signals that are interpreted by the control circuitry to determine if the head is not aligned with the track. If the head is off-center, the control circuit moves the actuator arm accordingly. As the disk spins, the servo segments periodically rotate below the heads, so that the head location can be periodically computed and adjusted.

A continuous servo system is typically employed in a multi-disk drive unit. A continuous system has a magnetic head and an entire disk surface that are dedicated to sensing the location of the heads. The servo head is rigidly attached to the other magnetic heads, so that the head locations can be constantly monitored.

Hard disk drives that are used in portable computers are particularly susceptible to external shock and vibrational loads. An excessive shock or vibrational load may cause the magnetic head to move to an adjacent track. If this head movement occurs while the drive is writing data, the old data on the adjacent track will be lost. It is therefore desirable to have a disk drive unit which prevents data from being lost when the disk drive is subjected to an external load. Because of the periodic nature of sample servo systems, such systems are too slow to prevent at least some data from being lost, particularly if a high frequency shock were to occur while the head was between the servo segments of the track. Although continuous servo systems provide a faster response, such systems require a dedicated disk surface which

reduces the storage space of the overall system. It would therefore be desirable to have a system which would significantly reduce the probability of data loss, when the disk drive was subjected to shock or vibration of a magnitude that can move the actuator arm of the drive unit.

## SUMMARY OF THE INVENTION

The present invention is a sensor system which disables the write gate of a hard disk drive when the drive unit is subjected to a threshold level of shock or vibration. The sensor system includes a transducer which can sense any rotational acceleration of the disk drive. The transducer provides an output voltage that is proportional to the acceleration of the drive unit. The output voltage is compared to a reference voltage by a logic circuit which disables the write gate of the disk drive, if the output voltage of the transducer is equal to or greater than the reference voltage.

The reference voltage is typically set to approximate the amount of acceleration required to move the magnetic head of the drive off track approximately ± 10%. The present invention therefore prevents the magnetic head from writing on an adjacent track when the drive unit is subjected to an excessive shock or vibrational load. The sensing system provides almost instantaneous feedback so that loss of data on an adjacent track does not occur. The present invention also employs a tracking error system which does not require additional space on the magnetic disk.

Therefore it is an object of the present invention to provide a hard disk drive unit which prevents data from being lost when the drive unit is subjected to external shock or vibrational loads.

It is also an object of the present invention to provide a sensing system which disables the write gate of the disk drive almost instantaneously with the application of an external load of sufficient magnitude to push the head off-track by more than ± 10%..

## BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of the present invention will become more readily apparent to those ordinarily skilled in the art after reviewing the following detailed description and accompanying drawings, wherein:

Figure 1 is a top cross-sectional view of a hard disk drive of the present invention;

Figure 2 is a schematic of a control system of the disk drive of Fig. 1;

Figure 3 is a schematic of a PET chip of the control system;

Figure 4 is a schematic of the shock detector of the control system.

## DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings more particularly by reference numbers, Figure 1 shows a hard disk drive 10 of the present invention. The hard disk drive 10 includes a housing 12 that has a connector 14 which can be mated with a corresponding connector (not shown) located within a slot of a computer. The hard disk drive 10 is preferably constructed as a pluggable module which can be inserted into and detached from the computer. In the preferred embodiment, the housing is approximately 85.6 millimeters by 54.0 millimeters by 10.5 millimeters. The computer may be constructed to be portable and therefore susceptible to shock and vibrational loading.

Within the housing 12 is a magnetic disk 16 that is rotated by an electric motor (not shown). The drive unit 10 may contain a number of magnetic disks 16 that store information on both disk surfaces. Each disk surface is typically organized into a plurality of tracks 18 which each store digital information. The disks 16 rotate relative to magnetic heads 20 that are supported by actuator arms 22. The magnetic heads 20 are constructed to magnetize and sense the magnetic field of the magnetic disks 16.

Attached to the actuator arms 22 is a coil 24 that is coupled to a magnet 26. The actuator arms 22 can be moved relative to the disks 16 by energizing the coil 24. The coil 24 is used to move the magnetic heads 20 between the tracks 18 of the disk 16. The coil 24 and magnetic heads 20 are coupled to a printed circuit board 28 which contains a number of integrated circuits 30 that control the operation of the disk drive 10.

Figure 2 shows a schematic of the control circuitry the drive unit 10. The connector 14 is couple to a control board 32 which provides an interface to the computer system. The drive unit 10 also contains a microprocessor 34 that is connected to the controller 32 and a servo chip 36. The servo 36 is connected to the coil 26 and the electric motor of the disks 16. The servo 36 controls the movement of the actuator arms 22 and the location of the magnetic heads 20 relative to the disks 16.

In the preferred embodiment, the tracks 18 of each disk contain embedded information that is used to determine whether the magnetic heads 20 are centered within the track 18. The servo circuit 36 interprets the embedded information to determine the head position, and move the actuator arms 22 if the heads 20 are not aligned with the tracks 18.

The magnetic heads 20 are coupled to a preamplifier 38 and communicate with the remaining devices through a read/write (R/W) channel 40. The preamp 38 receives a write gate signal (not shown) when the magnetic heads 20 are writing information onto the disk 16, and a read gate signal (not shown) that is enabled when the heads are reading information from the disk. The disk drive 10 contains a PET chip 42 that is connected to a shock detector 44. The PET chip 42 disables the write gate when the shock detector 44 senses an acceleration of the disk drive 10 which exceeds a predetermined value. The acceleration threshold is typically below a calculated acceleration that would induce rotation of the actuator arms 22 and move the heads 20 off-track. By way of example, the threshold may be set for head movement of approximately $\pm$ 10% from the center of the track.

Disabling the write gate prevents data from being written over data on an adjacent track.

Figure 3 shows a preferred embodiment of the PET chip 42. The chip 42 includes a latch 46 which has a SET pin S connected to an AND gate 48 and a RESET pin R connected to the microprocessor 34. The input pins of the AND gate 48 are connected to the shock detector 44 and to the microprocessor 34 through an inverter 50. The output Q of the latch 46 is connected to an OR gate 52 which is also connected to the servo circuit 36. The output of the OR gate 52 is connected to AND gate 54. The write gate signal is routed through the AND gate 54 to the R/W channel 40 and preamp 38. The inverted output Q' of the latch 46 provides an input to the processor 34.

When the magnetic heads are writing, both the OR gate 52 and write signal are providing signals of the same state, which causes the AND gate 54 to output the same write gate signal that is being provided to the gate 54. When the write gate signal is in an enabled state, the OR gate output is normally in the same state, such that the preamp 38 is enabled and the magnetic heads 20 write data onto the disk 16. If the shock detector senses an acceleration above a threshold value, the detector 44 changes the state of the signal provided to the AND gate 48. The change in the detector output SETs the latch 48, which changes the state of the output at the OR gate 52 and the AND gate 54. Changing the state of the signal from the AND gate 54 disables the write gate of the read/write channel 40 and preamp 38, so that the magnetic heads 20 no longer write data onto the disk 16. The write gate can also be disabled by the servo 36, which may change the state of the signal provided to the OR gate 52. The servo 36 can be used to detect low frequency shock or vibrational loads, particularly loads that are less than 100 Hz.

When the latch has SET, the inverted output Q' provides an input to the processor which indicates that the disk drive is experiencing an excessive acceleration and that the write gate is disabled. The processor 34 typically maintains the latch 46 in the SET state until a predetermined amount of time has expired. In the preferred embodiment, the SET state is maintained up to one revolution of the disk. The microprocessor then RESETs the latch 46. If the disk drive 10 is still experiencing shock, the latch 46 will again SET and disable the write gate.

The shock detector 44 is constructed to sense any rotational acceleration of the disk drive. By way of example, the detector 44 may have acceleration sensors that are disclosed in U.S. Patent No. 4,718,276 issued to Laughlin, U.S. Patent No. 4,431,935 issued to Rider, or U.S. Patent No. 4,996,878 issued to Kubler, which are hereby incorporated by reference. Such transducers provide an output voltage that is proportional to the rotational acceleration of the disk drive. As shown in Figure 4, the output of the transducer 46 is compared to a reference voltage by a comparator circuit 48. When the output voltage of the transducer 46 is at least equal to the reference voltage, the comparator circuit 48 changes the state of the output signal provided to the PET chip 42, which disables the write gate. The reference voltage is set at a value that correlates to an acceleration which could move the actuator arms 22 and magnetic heads 20 off-track. By way of example, the reference voltage may correlate to a rotational acceleration of 500 radians per second per second ($rad/sec^2$).

The present invention thus provides a sensing system which disables the write gate when the disk drive is subjected to an acceleration which may move the magnetic heads off-track.

While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art.

What is claimed is:

1. A hard disk drive assembly, comprising:

a housing;

a magnetic disk adapted to rotate relative to said housing, said magnetic disk having a plurality of tracks;

a magnetic head coupled to said magnetic disk, said magnetic head being adapted to write information on said tracks of said magnetic disk when in a write mode;

acceleration sensing means for sensing an acceleration of said magnetic housing; and,

logic means for terminating said write mode when said shock sensing means senses an acceleration which is at least equal to a predetermined value.

2. The assembly as recited in claim 1, wherein said shock sensing means senses rotational acceleration.

3. The assembly as recited in claim 1, wherein said predetermined shock value approximates an acceleration value that would cause said magnetic head to move from a center of said track.

4. The assembly as recited in claim 1, wherein said logic means includes comparator means for comparing an output voltage of a transducer with a reference voltage, and providing a detector output when said transducer output voltage is at least equal to said reference voltage, said detector output being provided to a latch which terminates said write mode of said magnetic head.

5. The assembly as recited in claim 4, wherein said logic means includes a servo which can terminate said write mode of said magnetic head when said magnetic head moves from one track to another track.

6. The assembly as recited in claim 5, wherein said logic means includes latch reset means for resetting said latch after a predetermined time interval.

7. A hard disk drive assembly, comprising:

a housing;

a magnetic disk adapted to rotate relative to said housing, said magnetic disk having a plurality of tracks;

an actuator arm pivotally connected to said housing;

a magnetic head connected to said actuator arm, said magnetic head being adapted to write information on said tracks of said magnetic disk in response to an enabling write gate signal, said magnetic head discontinues writing information when said write gate signal is disabled;

transducer means for providing a transducer output that is proportional to a rotational acceleration of said housing; and,

logic means for disabling said write gate signal when said transducer output is at least equal to a predetermined value.

8. The assembly means as recited in claim 7, wherein said logic means includes a latch that has an input coupled to said transducer means, said latch further having an output coupled to an AND gate that controls said write gate signal.

9. The assembly as recited in claim 8, wherein said logic means includes a servo that is coupled to said AND gate through an OR gate that is also connected to said latch output.

10. The assembly as recited in claim 9, wherein said logic means includes latch reset means for resetting said latch after a predetermined time interval.

11. A method for preventing an improper write of data on a magnetic disk of a hard disk drive, comprising the steps of:

a) writing data on a magnetic disk with a magnetic head;

b) sensing an acceleration of said magnetic head;

c) determining whether said acceleration is at least equal to a predetermined value; and,

d) terminating said writing of data if said acceleration is at least equal to said predetermined value.

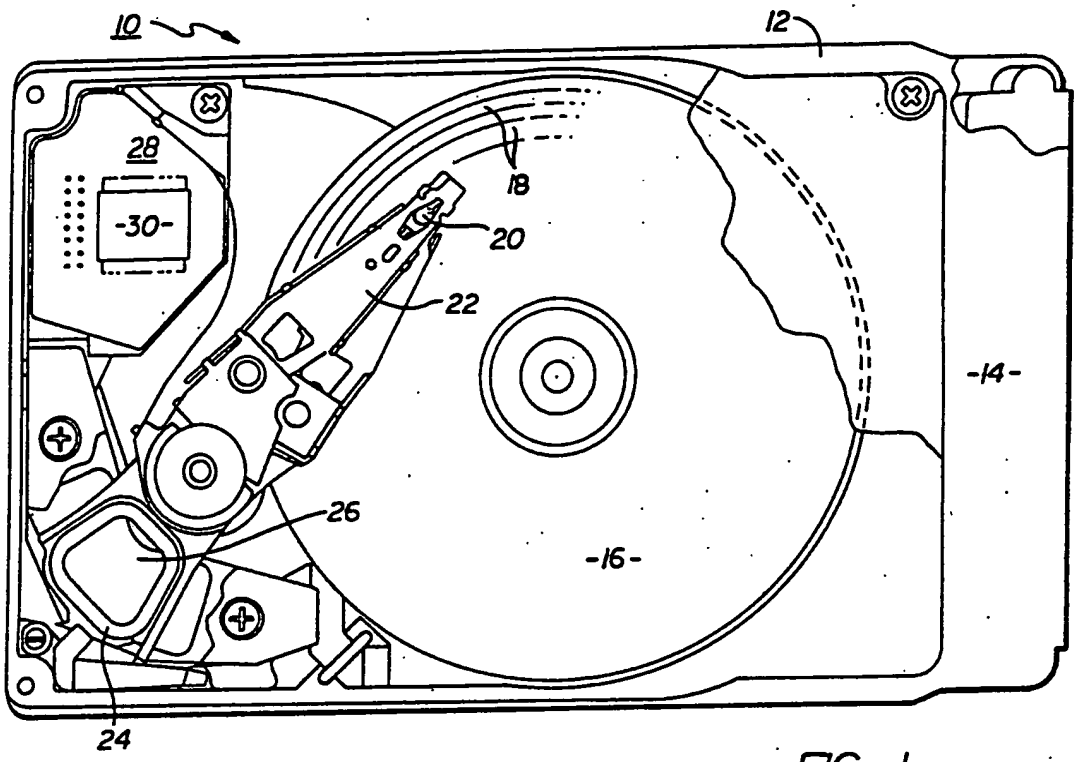

10
12
28
-30-
18
20
22
-14-
26
-16-
24

FIG. 1

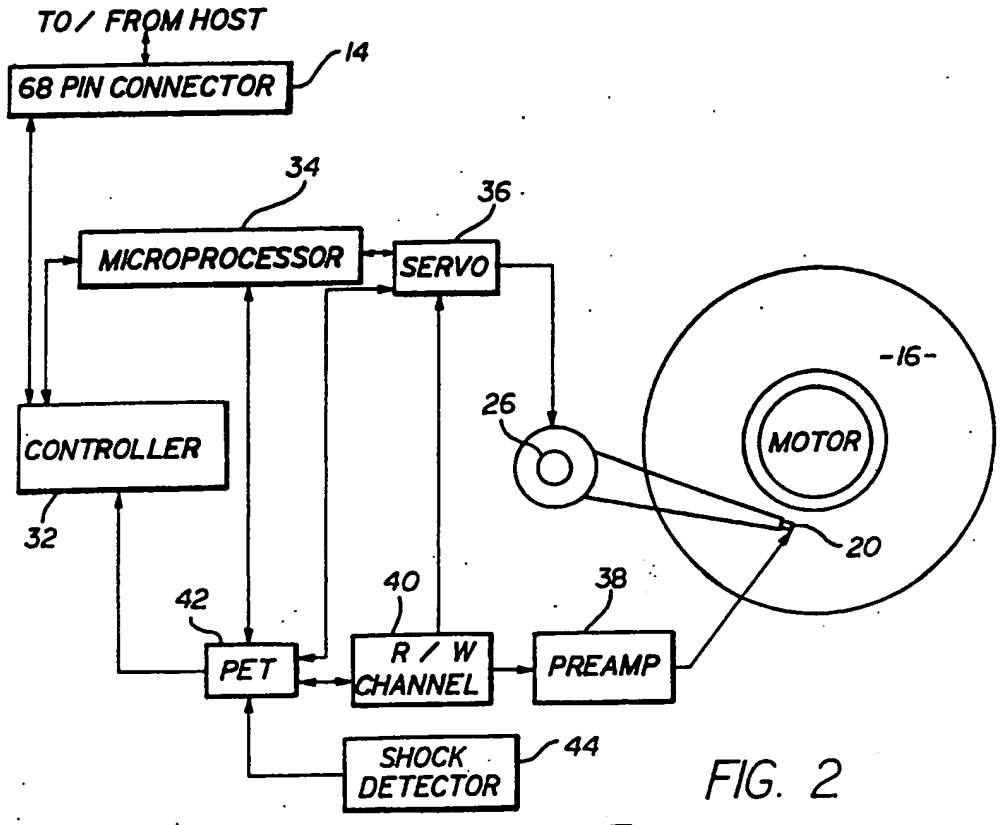
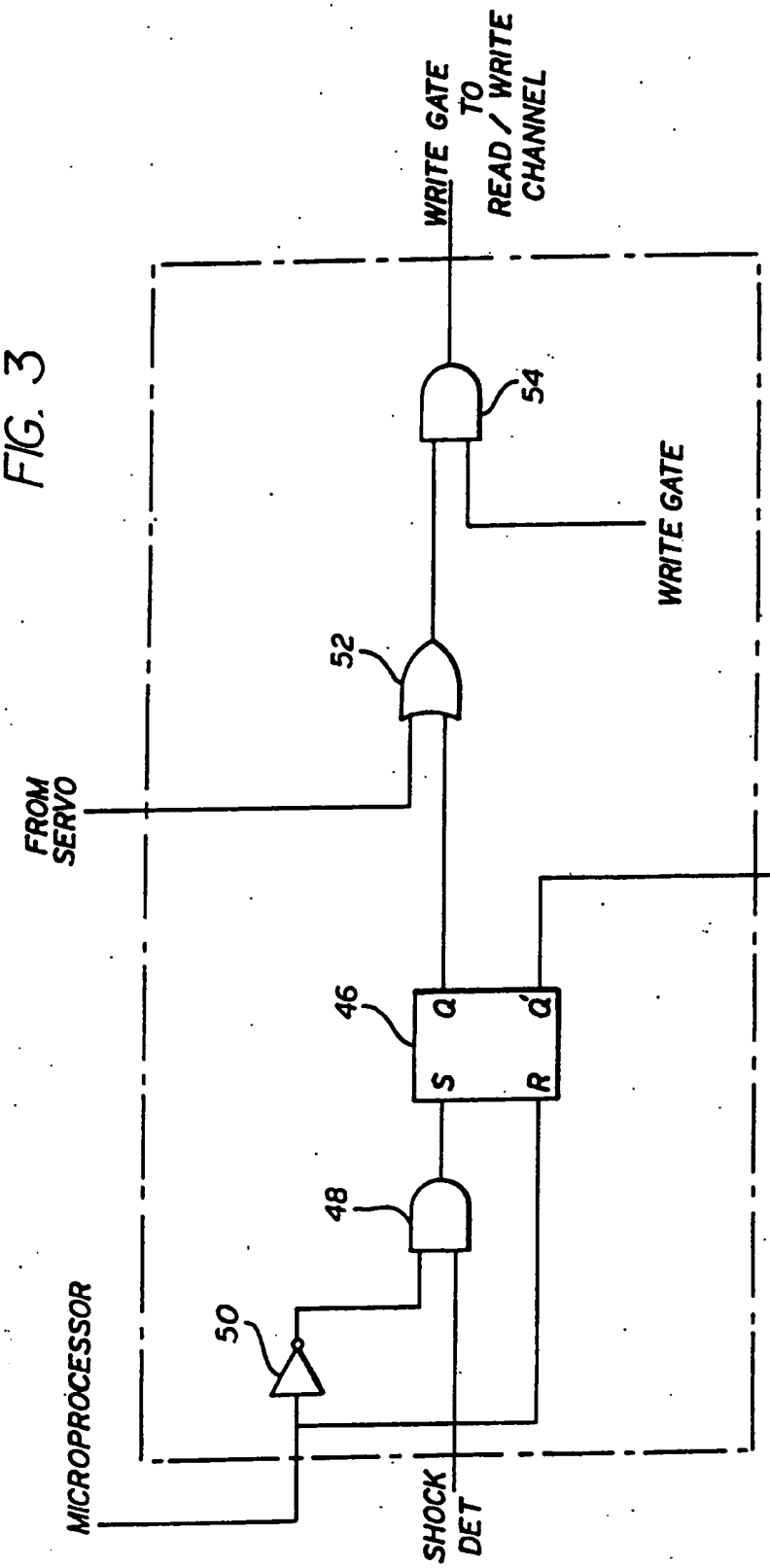

TO / FROM HOST
68 PIN CONNECTOR
14
34
MICROPROCESSOR
36
SERVO
-16-
26
MOTOR
CONTROLLER
32
20
42
40
38
PET
R / W CHANNEL
PREAMP
SHOCK DETECTOR
44

FIG. 2

FIG. 3


WRITE GATE TO READ / WRITE CHANNEL
54
WRITE GATE
52
FROM SERVO
MICROPROCESSOR
46
Q
Q'
S
R
48
50
MICROPROCESSOR
SHOCK DET

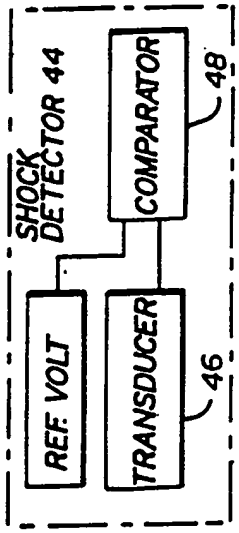

SHOCK DETECTOR 44
COMPARATOR
48
REF. VOLT
TRANSDUCER
46

FIG. 4

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/09856

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) : G11B 19/04
US CL : 360/60, 75
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 360/60, 75, 77.02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X/Y | US, A, 4,573,087 (TEZUKA ET AL) 25 FEBRUARY 1986, FIGURES 1,2 AND 4, COL. 3, LINE 3 THROUGH COL. 4, LINE 59. | 1, 3-6, 11/ 2, 7-10 |
| Y,P | US, A, 5,227,929 (COMERFORD) 13 JULY 1993, FIGURES 2-3, COL. 3, LINE 43 THROUGH COL. 4, LINE 32. | 1, 3-6, 11 |
| Y | US, A, 4,862,298 (GENHEIMER ET AL) 29 AUGUST 1989, FIGURE 3, COL. 4, LINE 37 THROUGH COL. 5, LINE 46. | 1, 3-5, 11 |
| Y | US, A, 4,692,915 (MORIYA ET AL) 08 SEPTEMBER 1987, FIGURES 1 AND 3, COL. 5, LINE 13 THROUGH COL. 9, LINE 53. | 1, 3-6, 11 |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

| | | | |
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| Date of the actual completion of the international search<br>22 November 1993 | Date of mailing of the international search report<br>07 DEC 1993 |
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# INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/09856

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US, A, 5,126,895 (YASUDA ET AL) 30 JUNE 1992, FIGURES 1, 3, AND 4, COL. 3, LINE 54 THROUGH COL. 5, LINE 42. | 1-11 |
| A | US, A, 4,967,293 (ARUGA ET AL) 30 OCTOBER 1990, FIGURES 5-7, AND 13. | 1, 3-6, 11 |

**Hotmail®** paulhansra@msn.com **Inbox | Previous Page**

**From :** "Paul HANSRA" <paulhansra@msn.com>
**To :** David_Sigmond@maxtor.com
**Subject :** Inventor Interviews in July
**Date :** Thu, 20 Mar 2003 23:36:54 -0800

Dear Dave:

I have contacted both Erhard Schreck (Disclosure No. 817) and Xioping Hu (Disclosure No. 823) to schedule inventor interviews in Milpitas on July 25, 2003. Both of the inventors indicated that they were available. I will provide you with the name of the conference room and the times of the interviews around the first week of July.

Regards,

Paul